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TRANSACTIONS

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VOL. XLVII.—PART III.—(No. 21).

# OBSERVATIONS ON THE BODY TEMPERATURE OF THE DOMESTIC FOWL (GALLUS GALLUS) DURING INCUBATION.

SUTHERLAND SIMPSON, M.D.

EDINBURGH:
PUBLISHED BY ROBERT GRANT & SON, 107 PRINCES STREET,
AND WILLIAMS & NORGATE, 14 HENRIETTA STREET, COVENT GARDEN, LONDON.

MDCCCCXI.

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# XXI.—Observations on the Body Temperature of the Domestic Fowl (Gallus gallus) during Incubation. By Sutherland Simpson, M.D. (From the Physiological Laboratory, Medical College, Cornell University, Ithaca, N.Y., U.S.A.) *Communicated by* Professor E. A. Schäfer, F.R.S.

(MS. received November 7, 1910. Read December 5, 1910. Issued separately January 13, 1911.)

## Introduction and Experiments.

It is held by many that the body temperature shows certain fixed diurnal and seasonal variations which cannot be accounted for by the action of the various influences, such as muscular exercise, ingestion of food, sleep, etc., which are known to affect the rate of heat production and heat loss. These variations are believed to be associated with corresponding changes in the tissue activities, and to a large extent to be independent of environmental conditions.

In this relation it is important to study the body temperature in association with the seasonal and other changes of habit which all animals exhibit to a greater or less degree, and, amongst homoiothermic animals, no class shows greater evidence of cyclical bodily changes than do birds. During moulting time, in the late summer and autumn, they shed their feathers and show other signs of depressed vitality, while in the spring, in preparation for the mating and breeding seasons, they put on fresh plumage and become extremely active. Then again during the incubation or brooding period the habits of the female bird, and in many cases also of the male, become greatly changed and the bodily activities profoundly modified.

No systematic investigation, so far as I know, has been made into the relationship which may exist between the body temperature of birds and these seasonal changes of habit, and although the whole problem is an extensive one calling for much detailed study, still, the effects of the natural alteration in the daily routine which takes place during the nesting or incubation period may be easily determined in the case of the domestic fowl.

It is a popular belief that the temperature of a brooding hen is above the normal; she is supposed to have "broody-fever." This I have gathered from conversations with poultrymen and farmers both in this country and in Scotland. That this should be the case seemed to me improbable, and to satisfy myself on the question I have made, within the last three years, three series of observations on the rectal temperature of brooding hens (*Gallus gallus*) and a fourth series has been made for me by Mr W. G. Krum, in charge of the poultry house in the Agricultural College, Cornell University.

On May 2nd, 1908, in Musselburgh, Scotland, I secured two hens (Dorkings) of the same brood, two years old. The one (A) was "broody"; the other (B), which I meant to use as a control, was a laying hen. They were kept in the same room with plenty of air-space, good light and ventilation, and under similar conditions with regard to food and external temperature. A nest made up of old rags and straw containing eight eggs was provided for A in a shallow open box in one corner of the room, on which she at once established herself, and B was allowed to roam about freely in the same room. The rectal temperature of each was recorded daily at 7 a.m., 7 p.m., midnight, and occasionally at more frequent intervals when opportunity permitted. Precautions were taken by gentle handling to avoid inaccurate readings which might possibly result from excitement or struggling, and the clinical thermometer used was inserted three inches into the cloaca and rectum and held in position for three minutes. The room temperature was taken at the same time. The readings obtained are shown in Table I.

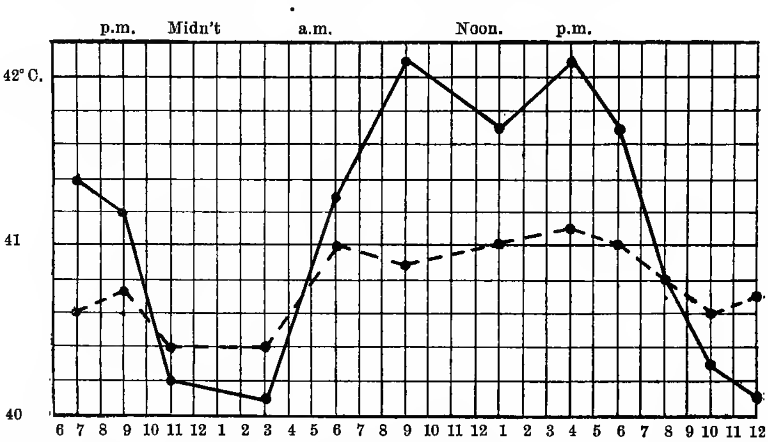

Fig. 1.—Chart showing temperature curves from hens A (interrupted line, brooding) at end of first week of incubation, and B (continuous line, control), May 9th and 10th. Observe that the 24-hour range in A (brooding) is much less than in B (control). The figures at the bottom indicate hours, and at the left side degrees centigrade.

From a glance at the figures it will be seen that during the day the temperature of the incubating hen is almost invariably lower than that of the active one, but at midnight, when the last observation for the day was made, it is usually higher. On four occasions, viz. 9th–10th, 16th–17th, 23rd–24th, and 30th–31st, continuous records were taken at short intervals throughout the twenty-four hours, and in all of these, with the exception of the last, this fact is brought out more clearly, viz. that during the day the rectal temperature of the brooding hen is lower than that of the control, while during the night the reverse is almost always the case. (See figs. 1 and 2.)

The last twenty-four-hour period came after the chicks were hatched—May 30th–31st,—and here the two curves run fairly parallel, the temperature of the mother hen, however, showing a greater range than that of her companion. (Fig. 2.)

Between 7 p.m. on the 22nd and 9 a.m. on the 23rd, four chicks were hatched. Subsequent examination of the remaining four eggs showed that one contained a dead chick, almost full time, while the other three were infertile.

## TABLE I.

*Records of Rectal Temperature from Hens* A (*Brooding*) *and* B (*Control*) *between May 3rd and* 31*st*, 1908.

| | A. | B. | Room. | |
|---|---|---|---|---|
| | ° C. | ° C. | ° C. | |
| May 3rd, 7 a.m. | 41·0 | 41·7 | 12 | |
| ,, ,, 7 p.m. | 41·7 | 41·7 | 14 | |
| ,, ,, 12 ,, | 40·5 | 40·3 | 12 | |
| ,, 4th, 7 ,, | 41·0 | 41·1 | 13 | |
| ,, 5th, 7 a.m. | 41·0 | 41·6 | 12 | |
| ,, ,, 7 p.m. | 40·8 | 40·7 | 13 | |
| ,, ,, 12 ,, | 40·4 | 40·5 | 11 | |
| ,, 6th, 7 a.m. | 40·8 | 41·6 | 13 | |
| ,, ,, 7 p.m. | 40·6 | 42·1 | 14 | |
| ,, ,, 12 ,, | 40·3 | 40·2 | 12 | |
| ,, 7th, 7 a.m. | 40·8 | 41·8 | 12 | |
| ,, ,, 7 p.m. | 40·9 | 40·3 | 14 | |
| ,, ,, 12 ,, | 40·4 | 40·1 | 11 | |
| ,, 8th, 7 a.m. | 40·5 | 41·5 | 13 | |
| ,, ,, 7 p.m. | 40·7 | 40·8 | 15 | |
| ,, ,, 12 ,, | 40·6 | 40·1 | 14 | |
| ,, 9th, 7 a.m. | 40·6 | 41·8 | 12 | |
| ,, ,, 7 p.m. | 40·6 | 41·4 | 14 | |
| ,, ,, 9 ,, | 40·7 | 41·2 | 14 | |
| ,, ,, 11 ,, | 40·4 | 40·2 | 13 | |
| ,, 10th, 3 a.m. | 40·4 | 40·1 | 12 | |
| ,, ,, 6 ,, | 41·0 | 41·3 | 12 | |
| ,, ,, 9 ,, | 40·9 | 42·1 | 13 | |
| ,, ,, 1 p.m. | 41·0 | 41·7 | 15 | |
| ,, ,, 4 ,, | 41·1 | 42·1 | 16 | |
| ,, ,, 6 ,, | 41·0 | 41·7 | 16 | |
| ,, ,, 8 ,, | 40·8 | 40·7 | 15 | |
| ,, ,, 10 ,, | 40·6 | 40·3 | 13 | |
| ,, ,, 12 ,, | 40·7 | 40·1 | 13 | |
| ,, 11th, 7 a.m. | 40·7 | 41·4 | 12 | |
| ,, ,, 7 p.m. | 40·6 | 40·9 | 15 | |
| ,, ,, 12 ,, | 40·1 | 40·3 | 13 | |
| ,, 12th, 7 a.m. | 40·8 | 41·5 | 12 | |
| ,, ,, 7 p.m. | 41·0 | 41·7 | 15 | |
| ,, ,, 12 ,, | 40·4 | 40·1 | 13 | |
| ,, 13th, 8 a.m. | 41·0 | 41·6 | 14 | |
| ,, ,, 7 p.m. | 40·9 | 41·9 | 16 | |
| ,, ,, 12 ,, | 40·2 | 40·2 | 14 | |
| ,, 14th, 7 a.m. | 40·6 | 41·4 | 13 | |
| ,, ,, 7 p.m. | 40·9 | 40·7 | 15 | |
| ,, ,, 12 ,, | 40·4 | 40·0 | 12 | |
| ,, 15th, 7 a.m. | 40·7 | 41·6 | 13 | |
| ,, ,, 7 p.m. | 41·0 | 40·2 | 14 | |
| ,, ,, 12 ,, | 40·3 | 40·2 | 12 | |
| ,, 16th, 7 a.m. | 41·0 | 41·9 | 13 | |
| ,, ,, 7 p.m. | 40·8 | 42·3 | 16 | |
| ,, ,, 12 ,, | 40·4 | 39·9 | 14 | |
| ,, 17th, 3 a.m. | 40·4 | 40·5 | 12 | |
| ,, ,, 6 ,, | 40·9 | 41·3 | 12 | |
| ,, ,, 9 ,, | 41·0 | 41·8 | 13 | |
| ,, ,, 12 ,, | 41·1 | 41·8 | 14 | |
| ,, ,, 3 p.m. | 40·8 | 41·4 | 15 | |
| ,, ,, 6 ,, | 40·7 | 41·6 | 14 | |
| May 17th, 9 p.m. | 40·3 | 40·0 | 13 | |
| ,, ,, 12 ,, | 40·4 | 39 9 | 13 | |
| ,, 18th, 7 a.m. | 40·6 | 41·4 | 14 | |
| ,, ,, 7 p.m. | 40·9 | 40·3 | 16 | |
| ,, 19th, 7 a.m. | 40·6 | 41·4 | 13 | |
| ,, ,, 7 p.m. | 41·0 | 40·2 | 14 | |
| ,, ,, 12 ,, | 40·5 | 40·8 | 12 | |
| ,, 20th, 7 a.m. | 41·1 | 41·3 | 14 | |
| ,, ,, 7 p.m. | 40·9 | 40·5 | 15 | |
| ,, ,, 12 ,, | 40·7 | 40·1 | 13 | |
| ,, 21st, 7 a.m. | 40·6 | 41·3 | 15 | |
| ,, ,, 7 p.m. | 40·8 | 40·8 | 16 | |
| ,, ,, 12 ,, | 40·5 | 40·4 | 12 | |
| ,, 22nd, 7 a.m. | 41 0 | 41·5 | 13 | |
| ,, ,, 7 p.m. | 41·4 | 40·1 | 13 | |
| ,, ,, 12 ,, | 41·0 | 40·3 | 11 | Hatching. |
| ,, 23rd, 4 a.m. | 40·6 | 40·6 | 11 | |
| ,, ,, 6 ,, | 41·5 | 41·6 | 12 | |
| ,, ,, 9 ,, | 41·6 | 41·7 | 12 | |
| ,, ,, 7 p.m. | 41·7 | 40·2 | 13 | |
| ,, ,, 9 ,, | 40·7 | 40·1 | 13 | |
| ,, 24th, 1 a.m. | 41·0 | 40·5 | 12 | |
| ,, ,, 3 ,, | 41·1 | 40·2 | 12 | |
| ,, ,, 6 ,, | 41·3 | 41·1 | 13 | |
| ,, ,, 9 ,, | 41·5 | 41·2 | 13 | |
| ,, ,, 12 ,, | 41·4 | 41·7 | 13 | |
| ,, ,, 3 p.m. | 42·2 | 41·8 | 14 | |
| ,, ,, 6 ,, | 42·2 | 41·3 | 14 | |
| ,, ,, 9 ,, | 41·1 | 40·6 | 13 | |
| ,, ,, 12 ,, | 41·0 | 40·4 | 13 | |
| ,, 25th, 3 a.m. | 40·2 | 40·5 | 12 | |
| ,, ,, 7 ,, | 41·9 | 41·7 | 13 | |
| ,, ,, 7 p.m. | 42·0 | 40·6 | 16 | |
| ,, ,, 12 ,, | 40·7 | 40·3 | 14 | |
| ,, 26th, 7 a.m. | 41·2 | 41·2 | 13 | |
| ,, ,, 7 p.m. | 41·9 | 41·4 | 15 | |
| ,, ,, 12 ,, | 40·4 | 40·7 | 12 | |
| ,, 30th, 7 p.m. | 41·6 | 41·8 | 14 | |
| ,, ,, 9 ,, | 40·9 | 40·6 | 14 | |
| ,, ,, 11 ,, | 40·5 | 40·7 | 13 | |
| ,, 31st, 1 a.m. | 40·3 | 40·4 | 13 | |
| ,, ,, 3 ,, | 40·5 | 40·8 | 12 | |
| ,, ,, 6 ,, | 42·1 | 41·3 | 14 | |
| ,, ,, 7 ,, | 42·0 | 41·9 | 14 | |
| ,, ,, 9 ,, | 42·2 | 41·7 | 15 | |
| ,, ,, 12 ,, | 42·4 | 41·2 | 15 | |
| ,, ,, 3 p.m. | 41·5 | 41·8 | 16 | |
| ,, ,, 6 ,, | 42·6 | 41·7 | 17 | |
| ,, ,, 7 ,, | 41·0 | 41·3 | 16 | |
| ,, ,, 9 ,, | 40·4 | 40·6 | 16 | |
| ,, ,, 12 ,, | 40·2 | 40·4 | 14 | |

In April and May 1909, in the Physiological Laboratory at Cornell University, two more experiments were made with incubating and control hens. A large wooden box placed on its side, with open front, was divided by a partition into two compartments of equal size, each about two feet high, with a floor space of a little over four square feet. On April 7th a "broody" hen (A′) was set on a nest containing eight eggs in one compartment, and a control hen (B′) of the same age and breed (Barred Plymouth Rock) was closed in the other compartment by a door of wire-netting. The room was small and dimly-lighted from a single window, and the ventilation was not all that could be desired. A′ left the nest occasionally to feed, and B′ was allowed to come out of the box and move about in the room for an hour or two daily, but was always shut in again at least one hour before the temperature was taken.

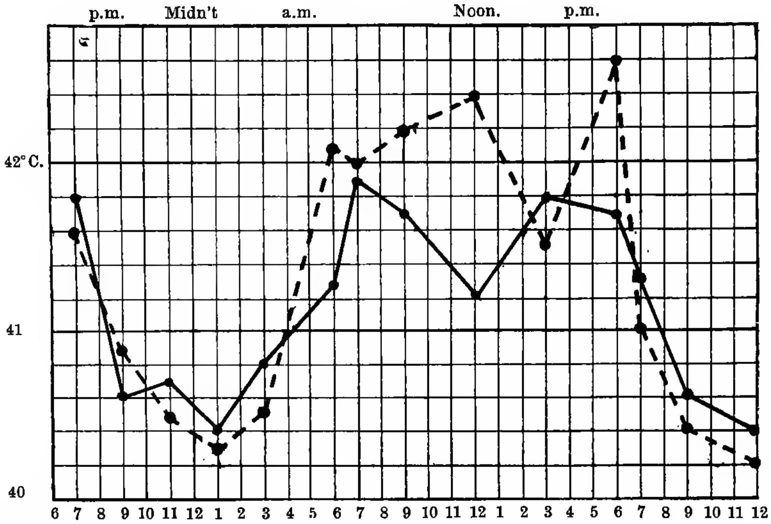

FIG. 2.—Chart showing temperature curves from A (interrupted line, brooding) one week after hatching out chicks, and B (continuous line, control), May 30th and 31st. The 24-hour range in A is now greater than in B.

On April 11th another pair of hens (Barred Plymouth Rock) were secured, one (A″) "broody," the other (B″) normal as a control. A″ was set on a nest with eight eggs in a corner of a large and well-ventilated room adjoining the small room mentioned above, and B″ was given its freedom in the same room.

In these two experiments, which were conducted in the animal house attached to the laboratory, the rectal temperatures were recorded daily at 9 a.m., noon, and 6 p.m. regularly, and on four occasions—April 13th–14th, 20th–21st, 27th–28th and May 4th–5th—readings were taken every three hours throughout the twenty-four. The figures (degrees centigrade), together with the room temperature, are given in Table II.

As no chicks appeared under A′ at the end of twenty-one days the eggs were opened, and three were found to contain dead chicks. The remaining five were unfertilised; three of them had been broken in the nest. On April 30th A′ and B′ were turned into the larger room along with A″ and B″. On May 1st and 2nd six chicks were hatched

## TABLE II.

*Records of Rectal Temperature from Hens* A′ *and* A″ (*Brooding*) *and* B′ *and* B″ (*Controls*) *between April 7th and May 5th*, 1909.

| 1909. | A′. | B′. | A″. | B″. | Room. | |
|---|---|---|---|---|---|---|
| | ° C. | ° C. | ° C. | ° C. | ° C. | |
| April 7th, 11 a.m. | 41·2 | 41·4 | ... | ... | 20 | |
| ,, ,, 3 p.m. | 41·2 | 41·7 | ... | ... | 21 | |
| ,, ,, 6 ,, | 40·5 | 40·7 | ... | ... | 22 | |
| ,, ,, 9 ,, | 40·3 | 40·7 | ... | ... | 20 | |
| ,, 8th, 9 a.m. | 40·6 | 41·6 | ... | ... | 21 | |
| ,, ,, 12 ,, | 40·8 | 42·0 | ... | ... | 23 | |
| ,, ,, 6 p.m. | 40·8 | 40·8 | ... | ... | 23 | |
| ,, 9th, 9 a.m. | 40·9 | 40·9 | ... | ... | 19 | |
| ,, ,, 12 ,, | 41·0 | 42·1 | ... | ... | 21 | |
| ,, ,, 6 p.m. | 40·6 | 41·8 | ... | ... | 22 | |
| ,, 11th, 9 a.m. | 40·7 | 41·1 | ... | ... | 21 | |
| ,, ,, 12 ,, | 40·8 | 40·8 | ... | ... | 23 | |
| ,, ,, 6 p.m. | 40·4 | 41·3 | 40·9 | 42·1 | 23 | |
| ,, 12th, 9 a.m. | 40·5 | 41·2 | 41·0 | 41·8 | 20 | |
| ,, ,, 12 ,, | 41·0 | 41·4 | 41·2 | 42·3 | 22 | |
| ,, ,, 6 p.m. | 41·1 | 41·8 | 40·6 | 41·7 | 23 | |
| ,, 13th, 9 a.m. | 41·2 | 42·0 | 40·9 | 42·3 | 21 | |
| ,, ,, 12 ,, | 40·7 | 42·1 | 40·8 | 41·6 | 21 | |
| ,, ,, 6 p.m. | 41·1 | 41·8 | 41·1 | 42·1 | 23 | |
| ,, ,, 9 ,, | 40·8 | 40·6 | 40·5 | 41·2 | 21 | |
| ,, ,, 12 ,, | 40·6 | 40·5 | 40·6 | 40·5 | 19 | |
| ,, 14th, 3 a.m. | 40·9 | 40·4 | 40·5 | 40·5 | 18 | |
| ,, ,, 6 ,, | 40·9 | 41·0 | 40·6 | 41·2 | 18 | |
| ,, ,, 9 ,, | 41·5 | 41·8 | 41·1 | 41·9 | 19 | |
| ,, ,, 12 ,, | 41·2 | 42·0 | 41·0 | 42·1 | 21 | |
| ,, ,, 3 p.m. | 41·4 | 41·7 | 40·8 | 41·6 | 21 | |
| ,, ,, 6 ,, | 41·5 | 42·0 | 41·2 | 42·2 | 19 | |
| ,, ,, 9 ,, | 41·2 | 40·8 | 40·7 | 40·6 | 18 | |
| ,, ,, 12 ,, | 41·1 | 40·5 | 40·5 | 40·7 | 20 | |
| ,, 15th, 9 a.m. | 41·5 | 41·6 | 41·3 | 41·6 | 22 | |
| ,, ,, 12 ,, | 40·9 | 41·2 | 41·1 | 42·0 | 22 | |
| ,, ,, 6 p.m. | 41·4 | 41·8 | 40·5 | 41·4 | 19 | |
| ,, 16th, 9 a.m. | 41·4 | 41·8 | 40·4 | 42·5 | 20 | |
| ,, ,, 12 ,, | 41·3 | 42·1 | 40·8 | 41·6 | 22 | |
| ,, ,, 6 p.m. | 40·8 | 42·2 | 40·6 | 41·7 | 21 | |
| ,, 17th, 9 a.m. | 41·6 | 40·8 | 41·0 | 41·8 | 20 | |
| ,, ,, 12 ,, | 41·5 | 41·9 | 41·0 | 42·6 | 22 | |
| ,, ,, 6 p.m. | 41·2 | 41·7 | 40·6 | 42·5 | 23 | |
| ,, 18th, 9 a.m. | 40·8 | 41·2 | 40·7 | 42·1 | 18 | |
| ,, ,, 12 ,, | 41·4 | 42·1 | 41·0 | 41·8 | 19 | |
| ,, ,, 6 p.m. | 41·4 | 41·4 | 40·9 | 41·2 | 23 | |
| ,, 19th, 9 a.m. | 41·1 | 42·0 | 41·4 | 42·1 | 20 | |
| ,, ,, 6 p.m. | 40·9 | 41·8 | 41·0 | 40·7 | 22 | |
| ,, 20th, 9 a.m. | 41·3 | 41·6 | 41·4 | 42·4 | 19 | |
| ,, ,, 12 ,, | 41·0 | 42·0 | 41·2 | 41·9 | 23 | |
| ,, ,, 6 p.m. | 41·4 | 42·1 | 41·0 | 41·3 | 23 | |
| ,, ,, 9 ,, | 41·1 | 41·8 | 40·5 | 40·6 | 21 | |
| ,, ,, 12 ,, | 40·8 | 40·4 | 40·7 | 40·4 | 21 | |
| ,, 21st, 3 a.m. | 40·7 | 40·1 | 40·5 | 40·8 | 19 | |
| ,, ,, 6 ,, | 41·4 | 41·4 | 41·0 | 41·6 | 18 | |
| ,, ,, 9 ,, | 41·2 | 42·1 | 40·8 | 42·0 | 20 | |
| ,, ,, 12 ,, | 41·1 | 41·6 | 41·2 | 42·2 | 23 | |
| ,, ,, 3 p.m. | 41·5 | 42·0 | 41·3 | 42·2 | 22 | |
| ,, ,, 6 ,, | 41·3 | 41·8 | 40·9 | 41·5 | 23 | |
| ,, ,, 9 ,, | 40·9 | 40·3 | 40·6 | 41·0 | 20 | |
| April 21st, 12 ,, | 40·8 | 40·5 | 40·6 | 41·2 | 20 | |
| ,, 22nd, 9 a.m. | 41·2 | 41·8 | 41·3 | 41·7 | 22 | |
| ,, ,, 12 ,, | 40·8 | 41·4 | 41·4 | 42·1 | 23 | |
| ,, ,, 6 p.m. | 41·0 | 41·7 | 40·8 | 41·0 | 23 | |
| ,, 24th, 9 a.m. | 41·4 | 41·8 | 41·2 | 41·7 | 20 | |
| ,, ,, 12 ,, | 41·3 | 42·0 | 40·8 | 42·1 | 21 | |
| ,, ,, 6 p.m. | 40·8 | 41·6 | 41·1 | 41·2 | 20 | |
| ,, 25th, 9 a.m. | 41·3 | 41·6 | 41·6 | 41·7 | 18 | |
| ,, ,, 12 ,, | 41·7 | 41·0 | 41·7 | 40·9 | 23 | |
| ,, ,, 6 p.m. | 41·2 | 41·8 | 41·4 | 41·9 | 22 | |
| ,, 26th, 9 a.m. | 41·6 | 41·9 | 40·8 | 42·1 | 19 | |
| ,, ,, 12 ,, | 41·7 | 41·5 | 41·3 | 41·8 | 22 | |
| ,, ,, 6 p.m. | 41·2 | 42·0 | 40·9 | 42·2 | 23 | |
| ,, 27th, 9 a.m. | 41·1 | 41·1 | 41·3 | 41·9 | 20 | |
| ,, ,, 12 ,, | 41·2 | 42·2 | 41·4 | 42·1 | 23 | |
| ,, ,, 6 p.m. | 41·6 | 41·9 | 40·8 | 42·1 | 23 | |
| ,, ,, 9 ,, | 41·4 | 40·6 | 40·5 | 41·0 | 21 | |
| ,, ,, 12 ,, | 40·8 | 40·3 | 40·6 | 40·7 | 20 | |
| ,, 28th, 3 a.m. | 40·8 | 40·4 | 40·6 | 40·4 | 19 | |
| ,, ,, 6 ,, | 41·2 | 41·6 | 41·0 | 41·6 | 19 | |
| ,, ,, 9 ,, | 41·1 | 41·9 | 41·2 | 42·1 | 21 | |
| ,, ,, 12 ,, | 41·4 | 41·5 | 41·0 | 41·8 | 23 | |
| ,, ,, 3 p.m. | 41·5 | 41·9 | 40·8 | 42·4 | 22 | |
| ,, ,, 6 ,, | 41·0 | 41·6 | 41·1 | 42·1 | 23 | |
| ,, ,, 9 ,, | 41·1 | 40·7 | 40·7 | 41·2 | 21 | |
| ,, ,, 12 ,, | 40·7 | 40·3 | 40·6 | 40·3 | 20 | |
| ,, 29th, 9 a.m. | 41·3 | 41·8 | 41·4 | 41·9 | 21 | |
| ,, ,, 12 ,, | 41·8 | 41·7 | 41·7 | 41·7 | 23 | |
| ,, ,, 6 p.m. | 41·1 | 41·6 | 41·5 | 41·9 | 24 | |
| ,, 30th, 9 a.m. | 41·8 | 42·1 | 42·0 | 41·9 | 22 | |
| ,, ,, 12 ,, | 41·2 | 41·4 | 41·5 | 42·1 | 24 | |
| ,, ,, 6 p.m. | 40·9 | 41·8 | 41·8 | 42·0 | 23 | |
| May 1st, 9 a.m. | 41·2 | 41·9 | 41·8 | 42·0 | 20 | Hatching. |
| ,, ,, 12 ,, | 41·6 | 41·9 | 41·9 | 42·3 | 22 | |
| ,, ,, 6 p.m. | 42·1 | 42·1 | 42·3 | 41·8 | 19 | |
| ,, 2nd, 9 a.m. | 40·8 | 41·2 | 41·8 | 41·6 | 20 | |
| ,, ,, 12 ,, | 42·2 | 41·9 | 42·4 | 41·9 | 21 | |
| ,, ,, 6 p.m. | 42·0 | 42·1 | 42·1 | 41·9 | 23 | |
| ,, 3rd, 9 a.m. | 41·6 | 41·4 | 41·6 | 42·1 | 18 | |
| ,, ,, 12 ,, | 42·1 | 41·8 | 42·4 | 41·9 | 20 | |
| ,, ,, 6 p.m. | 42·2 | 41·6 | 42·1 | 40·9 | 21 | |
| ,, 4th, 9 a.m. | 40·9 | 41·8 | 42·1 | 42·1 | 20 | |
| ,, ,, 12 ,, | 41·8 | 42·1 | 41·9 | 42·0 | 22 | |
| ,, ,, 6 p.m. | 42·2 | 41·7 | 42·1 | 41·8 | 23 | |
| ,, ,, 9 ,, | 41·4 | 41·2 | 41·4 | 41·3 | 21 | |
| ,, ,, 12 ,, | 40·6 | 40·8 | 40·8 | 40·3 | 19 | |
| ,, 5th, 3 a.m. | 40·5 | 40·7 | 40·4 | 40·7 | 18 | |
| ,, ,, 6 ,, | 41·6 | 40·9 | 41·2 | 40·9 | 18 | |
| ,, ,, 9 ,, | 42·4 | 41·8 | 42·3 | 41·9 | 20 | |
| ,, ,, 12 ,, | 41·9 | 42·1 | 42·5 | 42·2 | 22 | |
| ,, ,, 3 p.m. | 42·3 | 42·1 | 41·9 | 42·1 | 23 | |
| ,, ,, 6 ,, | 42·1 | 41·8 | 42·3 | 41·8 | 23 | |
| ,, ,, 9 ,, | 41·6 | 41·0 | 41·4 | 41·6 | 20 | |
| ,, ,, 12 ,, | 40·4 | 40·6 | 40·6 | 40·7 | 18 | |

by A″; two died on May 3rd, and the remaining four were mothered by both A′ and A″.

Both B′ and B″ were laying throughout the whole period at the rate of one egg every second or third day. Although B′ was confined in a narrow space it appeared to be a particularly active bird; when observed during the day it was rarely sitting, but nearly always standing or walking backwards and forwards within the narrow limits of its cage. In this respect its selection as a control was unfortunate, since I was desirous of having a resting but non-incubating hen.

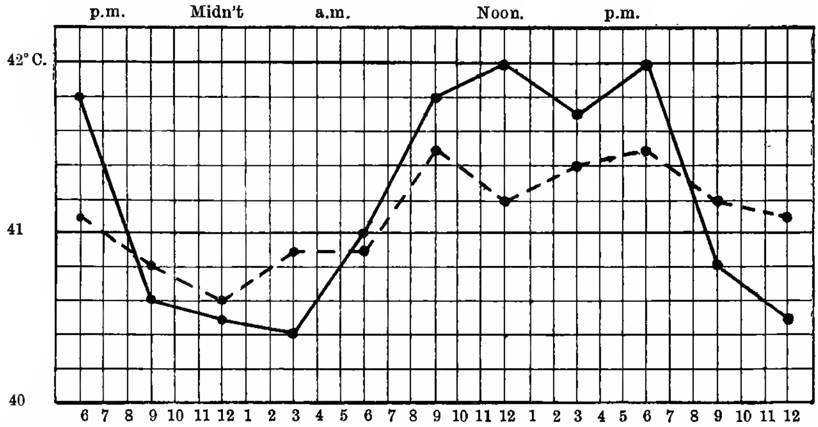

Fig. 3.—Chart showing temperature curves of hens A′ (interrupted line, brooding) at end of first week of incubation, and B′ (continuous line, control), April 13th and 14th.

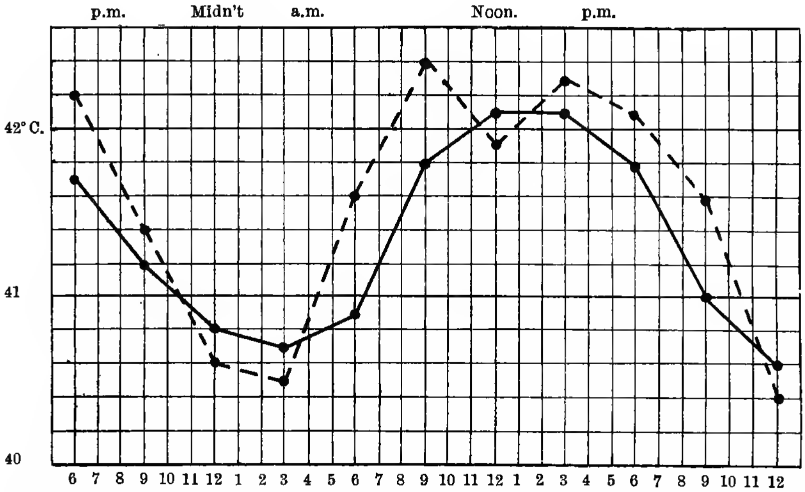

Fig. 4.—Chart showing temperature curves of hens A′ (interrupted line, brooding) one week after end of incubation period, and B′ (continuous line, control), May 4th and 5th.

A further series of observations was made for me in May and June by Mr W. G. Krum, to whom I would take this opportunity of expressing my thanks. Three "broody" hens were selected (C, C′, C″); the rectal temperature was taken at noon on May 23rd, 24th, and 25th, and on the 26th they were set on duck's eggs and the temperature recorded at the same hour (noon) daily, with one or two interruptions, until three days after the ducklings were hatched. One of the hens became sick and died in the third week of incubation. This is the only series in which observations were made immediately before the brooding period began as well as after the hatching was completed. (Table III.)

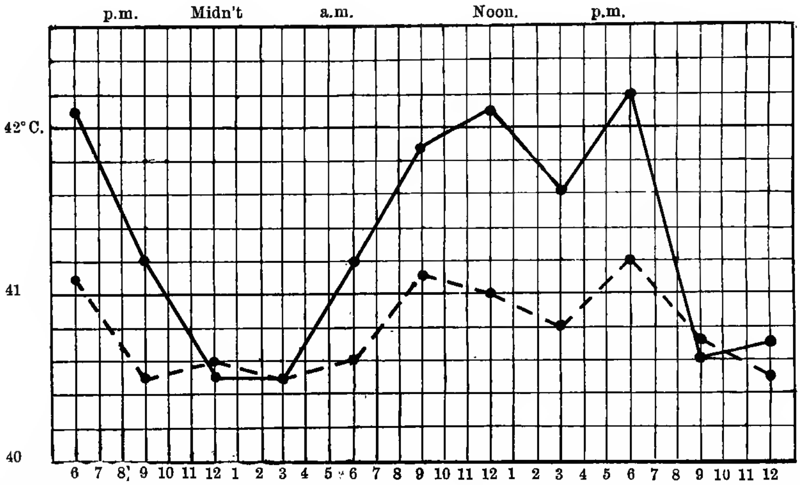

Fig. 5.—Chart showing temperature curves of Hens A″ (interrupted line, brooding) on third and fourth days of incubation, and B″ (continuous line, control), April 13th and 14th.

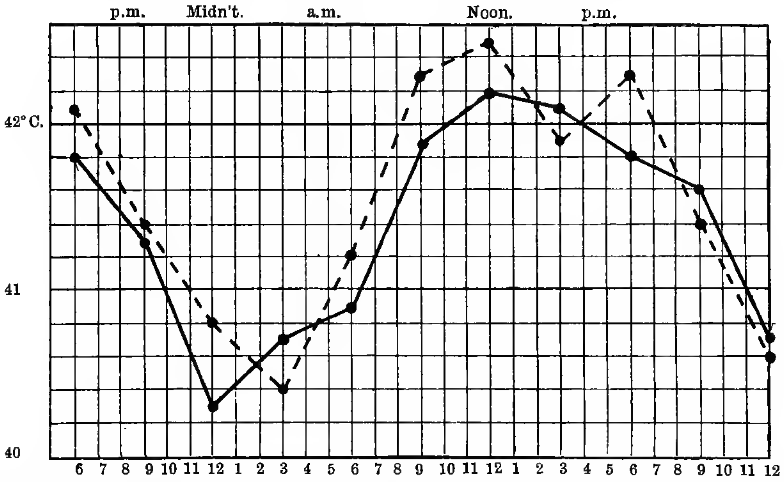

Fig. 6.—Chart showing temperature curves of Hens A″ (interrupted line, brooding) on third and fourth days after hatching out chicks, and B″ (continuous line, control), May 4th and 5th.

TABLE III.

*Records of Rectal Temperature from two Brooding Hens, C and C′, taken at noon before, during, and after incubation. The Mean Temperature for three days before incubation, for each week during incubation, and for three days after hatching is also shown.*

| 1909. | C. | C′. | Room. | 1909. | C. | C′. | Room. |
|---|---|---|---|---|---|---|---|
| | ° C. | ° C. | ° C. | | ° C. | ° C. | ° C. |
| May 23 | 42·1 | 41·8 | ... | June 8 | 40·7 | 40·6 | 18 |
| „ 24 | 41·8 | 41·7 | ... | „ 9 | 40·6 | 41·0 | 17 |
| „ 25 | 42·1 | 41·9 | ... | „ 10 | 41·2 | 41·3 | 21 |
| | | | | „ 13 | 41·2 | 41·6 | 21 |
| | | | | „ 14 | 41·0 | 41·3 | 23 |
| „ 26 | 41·6 | 41·1 | 23 | „ 15 | 41·3 | 41·7 | 24 |
| „ 27 | 41·0 | 41·1 | 24 | „ 16 | 41·2 | 41·0 | 19 |
| „ 28 | 41·4 | 41·7 | 16 | „ 17 | 41·0 | 40·5 | 10 |
| „ 30 | 41·4 | 41·0 | 21 | „ 18 | 40·6 | 40·6 | 23 |
| „ 31 | 41·6 | 41·1 | 24 | „ 19 | Hatching | | ... |
| June 1 | 41·7 | 41·4 | 24 | „ 20 | „ | | ... |
| „ 2 | 41·5 | 41·1 | 26 | | | | |
| „ 3 | 41·4 | 40·7 | 27 | | | | |
| „ 5 | 41·2 | 41·0 | 21 | „ 21 | 42·2 | 41·3 | 27° |
| „ 6 | 40·5 | 40·4 | 18 | „ 22 | 42·2 | 42·2 | 31 |
| „ 7 | 41·0 | 40·7 | 21 | „ 23 | 41·4 | 41·2 | 22 |
| Before brooding | | | | | 42·0 | 41·8 | |
| First week | | | | | 41·45 | 41·23 | |
| Second week | | | | | 41·17 | 40·84 | |
| Third week | | | | | 41·01 | 41·12 | |
| After hatching | | | | | 41·93 | 41·57 | |

## COMPARISON OF RESULTS WITH THOSE OF FORMER OBSERVERS AND CONCLUSIONS TO BE DRAWN FROM THEM.

On consulting Professor RICE, of the New York State Agricultural College, as to the existence of any data on the subject before beginning the second set of experiments, he informed me that some observations had been made in his department in 1903 by Messrs H. F. PRINCE and H. JENNINGS, and gave me access to the figures. They found no marked difference in the temperature of the hen from the time she began to incubate to the time she hatched. . . . "The point to notice is that the broody temperature was not abnormally low or abnormally high. It was rather under what we would expect to find in broody hens if they actually had a so-called broody fever" (1). They also found incidentally that the rectal temperature of hens which had just deposited an egg was about two degrees (Fahrenheit) above the normal, due to the exertion and excitement attendant upon the operation.

In 1907 A. C. EYCLESHYMER (2) studied experimentally many factors in the natural and artificial incubation of the eggs of the common fowl, and amongst others, the temperature of the fowl and of the eggs during incubation. In one set of experiments, in order to avoid disturbing the hen in determining its temperature, special self-registering thermometers were fastened to blocks so cut that their upper surfaces in contact with the hen's body were egg-shaped, the lower surfaces being broad and flat so that they could not be overturned. One of these was placed in each of four nests and left for two or three hours when the reading was made. A second set of readings was obtained from another group of four hens by gently removing the hen from the nest and placing the thermometer in the groin for five minutes. It is not stated at what hour of the day the temperatures were taken, nor whether they were taken at the same hour on successive days. This is a point of considerable importance. In both sets the temperature was found to be lowest the first day, and lower on the first three or four days than on the subsequent days of incubation.

One of EYCLESHYMER's objects being to find the temperature of the egg on successive days of incubation, this was carefully recorded by a special method, the temperature of the hen being taken at the same time. For the purpose of comparing his results with mine I show the figures he obtained for two series of observations. (Compare Tables IV. and V.) In the first (I.) the temperature of the hen was taken by the self-registering thermometer described above; in the second (II.) by a clinical thermometer placed in the groin; in both, the temperature record being that of the under surface of the body which came into direct contact with the eggs.

The surface temperature of the hen would therefore appear to rise slowly till about the end of the first week, and after that to remain more or less constant; the temperature of the egg, on the other hand, increases steadily to the end of incubation. According to my observations, which agree with those made in Professor RICE's department, the *internal* temperature of the incubating hen remains about the same level from the first day until the beginning of hatching, when there is a slight rise, which is probably to be accounted for by the increased excitement of the hen at that time. EYCLESHYMER's figures are from a single observation daily—he does not say at what hour; mine show the mean of three daily observations made at corresponding hours on successive days.

The fact that the surface temperature of the hen rises gradually during the first few days of incubation has also been noted by CYPHERS (3). He says: "If during the first few days of incubation we place a suitable thermometer beneath the hen in about the same position as the eggs are placed, there will be imparted to it a temperature of about 101° F. (38·3° C.) only, although a glass placed in the rectum will register from 109 to 110 (42·8° to 43·3° C.). . . . By the end of the first week of incubation the temperature in the rectum will be about 109; by the end of the second week it will have fallen to 108; and sometimes by the end of the third week to 106 degrees. One hen with a rectum temperature of 106 at the end of incubation was killed the fourth day following, and was found to have a temperature in the region of the heart of 110° F. (43·3° C.).

### Table IV.

*Mean Temperatures from three Observations made at the same hours* (7 *a.m.*, 7 *p.m.*, *and midnight in the case of* A *and* B; 9 *a.m.*, *noon*, *and* 6 *p.m. in the case of* A′, A″, B′, *and* B″) *in Hens* A, A′, A″ (*Incubating*) *and* B, B′, B″ (*Controls*), *during the whole period of incubation and five days after hatching.*

| Hen. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | ... |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | |
| A | 41·07 | ... | 40·73 | 40·57 | 40·7 | 40·6 | 40·53 | 40·9 | 40·47 | 40·73 | 40·7 | 40·63 | ... |
| B | 41·23 | ... | 40·93 | 41·30 | 40·73 | 40·80 | 41·13 | 41·03 | 40·87 | 41·10 | 41·23 | 40·70 | ... |
| A′ | ... | 40·73 | 40·83 | ... | 40·63 | 40·87 | 41·0 | 41·40 | 41·27 | 41·17 | 41·43 | 41·20 | ... |
| B′ | ... | 41·47 | 41·60 | ... | 41·07 | 41·47 | 41·97 | 41·93 | 41·53 | 42·03 | 41·47 | 41·57 | ... |
| A″ | 40·93 | 40·93 | 41·10 | 40·97 | 40·60 | 40·87 | 40·87 | ... | 41·20 | 40·97 | 41·17 | ... | ... |
| B″ | 41·93 | 42·00 | 42·07 | 41·67 | 41·93 | 42·30 | 41·70 | ... | 41·87 | 41·90 | 41·60 | ... | ... |

| Hen. | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. |
| A | 40·67 | 40·73 | 40·70 | ... | 40·70 | 40·90 | 40·63 | 41·13 | 41·40 | 41·50 | 41·53 | 41·17 | 41·00 |
| B | 40·67 | 41·37 | 40·93 | ... | 40·80 | 40·63 | 40·83 | 40·63 | 40·77 | 40·93 | 40·87 | 41·10 | 41·03 |
| A′ | ... | 41·23 | 41·20 | 41·00 | ... | 41·17 | 41·40 | 41·50 | 41·31 | 41·17 | 41·40 | 41·30 | 41·63 |
| B′ | ... | 41·90 | 41·83 | 41·63 | ... | 41·80 | 41·47 | 41·80 | 41·73 | 41·67 | 41·70 | 41·77 | 41·97 |
| A″ | 41·03 | 41·57 | 41·00 | 41·17 | 41·10 | 41·53 | 41·77 | 42·00 | 42·10 | 42·03 | 42·03 | 42·70 | ... |
| B″ | 41·67 | 41·50 | 42·03 | 42·03 | 42·00 | 41·83 | 42·00 | 42·03 | 41·80 | 41·63 | 41·97 | 41·97 | ... |

After hatching.

According to Cyphers, the reason why the temperature of the egg rises from the beginning to the end of incubation is to be found in the fact that in the early days a layer of down or feathers intervenes between the body and the eggs, but as incubation progresses the feathers covering the abdomen either fall off or are plucked off, and the eggs are then brought into direct contact with the incubating body of the hen, "so that notwithstanding the greater body temperature of the hen at the commencement of incubation, the temperature of the surface which imparts the warmth to the egg is not much inferior during the later stages of incubation to that of the earlier."

From Eycleshymer's experiments it would appear that the surface temperature of the hen rises gradually throughout the early days of incubation along with the temperature of the egg, while Cyphers says that the rectal temperature falls as that of the egg rises. Both omit to mention at what hour the records were made. In my experiments I find that there is practically no change in the rectal temperature of the incubating hen from the commencement to the end of the period, except that it appears to rise slightly

### TABLE V. (FROM EYCLESHYMER.)

*Surface Temperature of Hen compared with Temperature of Centre of Egg on Successive Days of Incubation. In Series I. the temperature was taken without disturbing the hen; in Series II. the hen was raised from the nest and a clinical thermometer placed in the groin.*

| I. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. | ° C. |
| Hen . . . | 39·0 | 39·4 | 39·7 | 40·0 | 39·9 | 40·5 | 40·3 | 40·3 | 40·5 | 40·5 |
| Egg . . . | 36·7 | 37·9 | 38·1 | 38·1 | 38·0 | 38·3 | 38·8 | 39·2 | 38·7 | 38·9 |
| I. | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Hen . . . | 40·4 | 40·6 | 40·3 | 40·5 | 40·6 | 40·5 | 40·3 | 40·4 | 40·3 | 40·3 |
| Egg . . . | 38·8 | 39·0 | 38·9 | 39·2 | 39·0 | 39·4 | 39·1 | 39·4 | 39·4 | 39·4 |
| II. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Hen . | 39·4 | 40·5 | 40·4 | 40·1 | 40·6 | 40·5 | 40·4 | 40·4 | 40·5 | 40·5 |
| Egg . . | 37·5 | 37·8 | 37·9 | 38·1 | 38·1 | 38·3 | 38·1 | 38·1 | 38·6 | 38·6 |
| II. | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Hen . . . | 40·4 | 40·5 | 40·4 | 40·4 | 40·6 | 40·5 | 40·8 | 40·0 | 40·0 | 40·0 |
| Egg . . . | 38·6 | 38·4 | 38·2 | 38·8 | 38·9 | 38·8 | 39·0 | 38·9 | 39·1 | 39·1 |

during the hatching. After the hatching is completed, and especially on the second and third days when the hen begins to move about and make provision for the wants of her brood, the body temperature rises distinctly and is higher than that of the control hen, a fact which is to be accounted for by the greater activity of the mother-hen.

However, while the temperature of the incubating hen is lower during the day than that of the control, during the night and early morning it is frequently higher, so that if the temperature means for the twenty-four hours are compared in the two cases, that of the brooding hen is only slightly the lower. (See Table VI.) The difference, therefore, is not to be found so much in the mean temperature as in the diurnal temperature range. This is greatly reduced in the brooding hen, so that the internal body temperature remains much more uniform throughout the whole period of incubation than in its ordinary active state. (See figs. 1, 3, and 5.) After hatching, the daily variation in the mother-hen is greater than in the control. (Figs. 2, 4, and 6.)

This uniformity in the temperature of the brooding hen is probably due entirely to the absence of the regular alternation of rest and activity, the lower temperature

TABLE VI.

*This shows the Mean Temperature of the Incubating and Control Hens for the twenty-four hours on the 8th, 15th, 22nd, and 29th days after the beginning of incubation.*

| Day of Incubation. | 8 | 15 | 22 | 29 |
|---|---|---|---|---|
| A | 40·79 | 40·66 | 41·42 | 41·38 |
| B | 41·03 | 40·91 | 40·98 | 41·19 |
| Day of Incubation. | 8 | 15 | 22 | 29 |
| A′ | 41·14 | 41·08 | 41·07 | 41·49 |
| B′ | 41·19 | 41·13 | 41·13 | 41·31 |
| Day of Incubation. | 4 | 11 | 18 | 25 |
| A″ | 40·78 | 40·84 | 40·84 | 41·49 |
| B″ | 41·26 | 41·43 | 41·40 | 41·33 |

during the night being associated with the depressant action of the darkness and silence on the bodily tone, in addition to the cessation of the coarser muscular movements. The fact that the temperature of the control is lower in the night than that of the brooding hen, may be explained as the result of the increased depression of function following on the more active condition during the day.

The curves of A′ and B′ (fig. 3) correspond more closely than either of the other two pairs, where B′ was kept in confinement to some extent, and from this we may conclude that the brooding condition of the hen has no relation to the modified character of the curve apart from its change of habit with regard to muscular activity; and if one could induce a non-brooding hen to remain quiescent for a similar period, the same result might be obtained. If the temperature of the brooding hen had been uniformly higher or lower than in the control, then it would be necessary to assume the existence of influences other than those which we know to affect directly the body temperature; but the modification in the temperature curve which does take place, is exactly what one would expect to find in association with the altered habits of the hen. The results, then, point to the conclusion that the diurnal variation in the body temperature is determined by the alternating states of rest and activity.

## SUMMARY.

1. The rectal temperature of the brooding hen shows little change throughout the whole period of incubation until the chickens begin to be hatched, when it rises perceptibly.

2. The mean temperature for the twenty-four hours is a few tenths of a degree below that of the control hen. The diurnal range is diminished, and, while the day temperature is lower than that of the control, the night temperature is usually higher.

3. For some days after hatching, the day temperature of the mother-hen is higher than that of the control and the range is greater.

4. The modification in the diurnal temperature curve during incubation is such as one would associate with the altered habits of the hen apart altogether from the brooding condition.

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| „ Part 2. | 1 1 0 | 0 16 0 |
| „ Part 3. | 0 16 0 | 0 12 0 |
| „ Part 4. | 0 7 6 | 0 5 8 |
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